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## (54) ELECTROLYTICALLY-GENERATED BACTERICIDAL SOLUTION

(71) We, MORTON-NORWICH PRODUCTS, INC., a corporation organised under the laws of the State of Delaware, United States of America, of 17 Eaton Avenue, Norwich, New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method of employing a bactericidal solution to disinfect a bacteria-laden surface, and to apparatus for applying the solution to a bacteria-laden surface.

In food processing plants, bottling plants, dairies and the like, it is essential that hygienic conditions should always be maintained. Thus, surfaces of physical objects in the plant are disinfected by the use of bactericidal sanitizing methods. The bactericides employed, particularly in food processing installations, must be safe and non-toxic when they are being used, and also must be safe and non-toxic in storage prior to use, and must furthermore leave no unsafe or toxic residues.

Several methods of applying bactericides are known. One common method is to wash all physical objects including walls and major items of equipment with a bactericidal solution containing bactericidal substances such as quaternary ammonium salts or chlorine. Chlorine solutions, for example, have been found to be fairly effective in killing bacteria in such cases. However, low pH chlorine solutions which are the most effective bactericides are so highly unstable and have such a limited shelf life that the storage and use of them as effective bactericides has heretofore been highly impractical. High pH solutions, on the other hand, in which chlorine is largely in the form of sodium or calcium hypochlorite, have a somewhat longer shelf life, but are less effective bactericides than the low pH solutions in which the chlorine is largely in the form of hypochlorous acid. To maintain high pH solutions in which the chlorine is in the more stable form, it is necessary that additives such as sodium hydroxide be added to the solution. Such additives, in addition to decreasing the bactericidal effectiveness of the solution, create an additional hazard in that a toxic and irritative solution is formed which leaves a toxic and irritative residue on the surfaces which are washed with the solution, which necessitates subsequent washing of these surfaces in order to remove this residue. Other additives, for example some used as stabilizers for calcium hypochlorite, form dangerously flammable compounds if not handled or stored properly. Since the most practical way of disinfecting the facilities in the food processing industry has been to wash the facility by spraying with the disinfecting solution, which solution has been purchased in bottle form and stored for at least a short period of time or premixed prior to use from powdered chemicals, the above-mentioned disadvantages have been inherent when such disinfecting methods have been used.

We have now developed a method of disinfecting a bacteria-laden surface with a bactericidal solution in which the predominant bactericidal constituent is hypochlorous acid.

Thus according to the invention there is provided a method of disinfecting a bacteria-laden surface, which comprises

(a) electrolysing an aqueous solution of sodium chloride having a pH of from 6 to 7, so as to generate nascent chlorine at least 80% of which is in the form of a hypochlorous acid, and

(b) substantially immediately applying the solution of nascent chlorine thus generated to the bacteria-laden surface.

SEE CORRECTION SLIP ATTACHED

Preferably a brine solution is formed to which an acid, preferably acetic acid, and water are added so that the resultant solution has a pH of from 6 to 7. That solution, when immediately electrolyzed, results in the production of chlorine in a bactericidal form of which at least 80% is hypochlorous acid.

The lowering of the pH of the solution from 6 to 7 is extremely important to the bactericidal efficacy of the subsequently electrolyzed solution. The following table illustrates the dramatic change with pH in the ratio of hypochlorous acid to other and less efficacious chlorine-containing constituents:

| *pH Value* | *% Hypochlorous Acid* |
|---|---|
| at 6.0 | 98% of total free $Cl_2$ |
| up to 6.7 | 95% ,, ,, ,, ,, |
| at 7.0 | 80% ,, ,, ,, ,, |
| at 8.0 | 21% ,, ,, ,, ,, |
| at 9.0 | 2.7% ,, ,, ,, ,, |
| at 10.0 | 0.3% ,, ,, ,, ,, |

While the lowering of the pH below 6 does not adversely affect the bactericidal properties of the solution, the solution tends to become quite corrosive and hence less desirable.

Further, it has been determined that low pH nascent chlorine, in the form of hypochlorous acid, is up to three times as effective as, or has three times the kill rate of, nascent chlorine in the form of hypochlorite.

The desired low pH bactericidal solution may be continuously formed by supplying metered amounts of glacial acetic acid to a brine solution, and the solution to be electrolysed may be formed by mixing the resultant solution with metered amounts of water. The amount of acetic acid employed in relation to the amounts of the other constituents is varied according to the pH of the incoming tap water employed.

The relatively low pH chlorine-containing solutions have high bactericidal effectiveness when employed substantially immediately after being generated, and do not give rise to the toxic or irritating residues which may be formed by some known bactericidal solutions.

The method according to the invention is particularly suitable for use in food plants and other places where high bactericidal effectiveness is required but where toxicity must be completely avoided. According to the invention, nascent chlorine is generated in a relatively low pH solution, in its most effective but least stable form, and is then sprayed in a continuous stream directly upon the surfaces to be disinfected immediately after the solution is generated, and before the solution is able to deteriorate to a less effective level, which results in an increased bactericidal effectiveness compared with known methods.

In addition to the higher bactericidal effectiveness of the bactericidal solutions and the reduced toxicity and irritability to living tissue of residues from such solutions, it has been found that the materials required cost only a small fraction of the cost of materials used in commonly employed known methods.

There are several other advantages which the present invention provides, particularly when compared with known methods in which a high pH hypochlorite solution is maintained by the addition of, for example, caustic lye. Nascent chlorine solutions can be detected by smell only at concentrations that are many times higher than for these known solutions. The same applies to detection by taste. Furthermore, the stable hypochlorite solutions will irritate the eyes and will bleach certain colours at far lower concentrations than will nascent chlorine. Nascent chlorine is also believed to be superior to the stable hypochlorite solution in its ability to reduce odours.

While electrolytic generation of chlorine for disinfecting and sanitizing purposes is known, the advantages of utilising nascent electrolytically generated chlorine for a spray solution, in industrially usable quantities, to sanitize bacteria-laden surfaces have not been disclosed. For example, electrolytic chlorine systems have been proposed for disinfecting a fluid or water supply by electrolytically generating chlorine in the solution which is to be disinfected to kill bacteria carried by the fluid. One such application has been in the disinfection of swimming pools. Such a method has also been used for deodorizing air; the decomposition and deterioration of the solution in which the chlorine is generated resulting in a dispersing of the bactericidal chlorine into the atmosphere which is to be disinfected.

The invention is particularly applicable to the disinfection of meat carcasses by spraying or washing the carcass with a low pH bactericidal solution of the invention, preferably having a chlorine concentration of from twenty-five to two hundred parts per million.

In the meat processing industry, the meat carcass after slaughtering is highly contaminated on its surface with bacteria. That surface contamination results in a considerable shortening of the shelf life of the meat, since when the carcass is cut up, and possibly ground (for example, to prepare ground beef), some of the bacteria on the surface of the meat becomes attached to freshly cut surfaces of the meat where they multiply and result in early spoilage of the meat. Numerous unsuccessful attempts have been made to solve this problem. Of

the attempts made, perhaps the one which most closely approaches a practical process involves washing the meat carcass with a commercial high pH hypochlorite solution of the type referred to above. This process, however, has been effective in eliminating only 90% of the bacteria. The remaining 10%, having the capability of migrating to, or being forced on to, interior surfaces of the meat and having the ability to multiply under the conditions of storage of the meat, still give rise to demonstrable spoilage. We have found that by washing the surface of the meat with a bactericidal solution produced in accordance with the present invention, the bacteria are entirely or substantially entirely eliminated from the surface of the meat; that is to say, the result ing bacteria are too few to count, indicating that the process is at least 99.99% effective.

In order that the invention may be more fully understood, a preferred embodiment thereof will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a preferred form of apparatus for generating a bactericidal solution for use in disinfecting a bacteria-laden surface according to the invention;

Figure 2 is a perspective view of a portable unit housing the disinfecting solution generating components, and of the portable wand of the apparatus illustrated in Figure 1; and

Figure 3 is a cross-sectional view of an electrolytic cell suitable for use in the apparatus of Figure 1.

Referring to Figure 1, the apparatus illustrated operates to spray a sanitizing liquid in the form of a continuous spray 10 directly upon the bacteria-laden surfaces to be disinfected, such as the walls and floors of the building structure 11 in, for example, food processing plants, or upon the surfaces of objects 12 such as machinery, furniture, or other equipment in such facilities.

The apparatus includes two independently movable parts which can be better seen by reference to Figure 2. These parts are the portable sanitizing solution generating unit 20 and the spray wand 30. The unit 20 includes a high grade stainless steel cabinet 21 mounted on casters 22 so that it can be rolled freely about a plant. Mounted on the front of the unit 20 are a power on-off switch 23, a power on indicator light 24, a chlorine solution output meter 25, and an operating instruction plate 26, all arranged on an operator panel 27. The unit 20 also includes a power line core 28 which is connectable either to a 220 volt AC or 110 volt AC power line, depending on the internal wiring of the unit 20.

The unit is provided with a liquid inlet port 29 connectable to a conventional tap water outlet of cold water, preferably supplied at a pressure of from 40 to 65 psi. The unit is further provided with two outlet ports for dispensing sanitizing fluids. These ports include a primary outlet port 31 and a bulk outlet port 33. When the system is operating according to the present invention, sanitizing solution will be emitted through the primary outlet port 31 and conducted through a hose 32 to the wand inlet port 35.

The unit 20 is also provided with an electrical connector 36 which connects through a control cable 37 to a trigger toggle switch 38 carried by the wand 30. The switch 38 provides a means for controlling operation of the generator unit 20 from the hand held wand 30 to selectively control the output of spray solution. The switch 38 is a three-position switch having an "OFF" position, a "sanitizing solution ON" position which causes the generation of sanatizing solution and the pumping of the solution to the wand 30, and a "flush ON" position in which unchlorinated water is communicated through the central unit and to the wand to flush the system.

The wand 30 is provided with a pistol grip-type handle 41, a fluid discharge nozzle 42, and a rigid tubular conduit 43 which communicates fluid from the wand inlet port 35 to the nozzle 42.

Referring again to Fig. 1, the internal and operative details of the wand assembly 30 and the central unit 20 are illustrated. The central unit 20 includes two basic sub-systems: the solution generating or fluid handling sub-system 50, and the electrical control system 110.

The solution generating system 50 includes a brine tank 52 in which a saline solution is prepared. This tank has a removable lid 53 fastened to the tank 52 by bolts 54. The lid 53 is removable so that salt 55 can be deposited in the tank, and so that the tank can be cleaned periodically. A level of water 56 is maintained in the tank 52 and the quantity of salt 55 is maintained at such a level that a saturated saline solution is formed in the water 56. The tank 55 is provided with an outlet pipe 57 which connects to the input of a positive displacement pump 58 which is driven by a motor 59. The pump 58 is a diaphragm type pump having a variable displacement which is controlled by a cam on the drive shaft 61 of the motor 59. The outlet of the pump 58 is connected through a check valve 62 to a "T" 63 which has an outlet connected to the inlet 66 at the bottom of the electrolytic cell 70.

The apparatus includes a system for supplying metered amounts of a food grade acid, preferably 85% glacial acetic acid, into the saline solution to lower its pH. If the

tap water and hence the saline solution is at pH of 7, then 2 oz. of acid for each gallon of water are required to achieve the desired pH level.

The acid is contained in a supply 75 connected through a line 76 which includes a pump 77 to the tank 52. Tank 52 is also supplied with fresh make-up water from the inlet port 29 via a line 78 which contains a throttle valve 79 and a flow switch 80. A float valve 81 connected to the line 78 detects the demand for additional solution as, for example, when the solution level drops by two gallons and permits water from the port 29 to flow through line 78 to the tank 52. The throttle valve is set to meter the fresh water at two gallons per minute.

The flow of water closes switch 80 causing pump 77 to operate to supply acid to the tank. The pump has a variable setting permitting the operator to meter the flow of acid to the tank in accordance with the flow of water and its pH. For example, if the water is at 7 pH, the pump would be set for 4 oz. per minute to result in 2 oz. of acid per gallon of make-up solution.

The clear water inlet 29 of the unit 20 is also connected through a solenoid controlled check valve 71 operated by a solenoid 72 and through a manually controlled needle valve 73 and a check valve 74 to the other input of the "T" 63. At the "T" 63, clear water from the input 29 is mixed with the saline solution from the tank 52 in ratios which are controlled by the combined settings of the cam on the pump motor input shaft 61 and the needle valve 73.

The combined solution enters the cell 70 at the cell input 66 and flows upwardly through the cell where the solution is electrolysed in a conventional manner, the electrolytic reaction causing chlorine gas to be formed and to combine with the other constituents of the solution to form principally hypochlorous acid ($HOCl$), certain other compounds such as sodium hypochlorite ($NaOCl$), and certain active free radicals, along with other byproducts of the reaction. The chlorinated solution, which is typically now at a pH of $6 \pm 0.1$, is emitted from the cell 70 at the outlet 69, into a "T" 68. The "T" 68 provides alternative outlets for the solution from the cell through a pair of manually controlled gate valves 64 and 65. The valve 65 controls the emission of bulk solution at the outlet 33 of the unit 20 in the event that it is wanted for use in sanitizing processes other than the spraying of physical objects. The gate valve 64 controls solution to the outlet 31 which connects to the hose 32 to communicate the electrolytically generated chlorinated sanitizing solution to the wand 30. This solution, when flowing, enters the wand 30 at the inlet 35 and is communicated through the tube 43 to the nozzle 42. All fluid fittings of the system are preferably constructed of either polyvinyl chloride or stainless steel to ensure high corrosion resistance.

The details of the cell 70 will be better understood by reference to Fig. 3. The cell 70 includes a cylindrical cell body 67 made of a non-corrosive metal or other non-corrosive material. The body is provided with an inlet 66 at the bottom end 82 thereof and, at its upper end, is provided with a flange 83. The cell head 85, made of electrically non-conductive material, is secured tightly to the top of the flange 83 by bolts 87 in such a way as to seal the interior 86 of the cell 70. The upper surface of the flange carries an O-ring 90 to effect a seal between the head 85 and the cell body 67. The cell head 85 is provided with an outlet passage 89 which communicates between an interior opening 88 at the center of the cell head 85 at a point between the electrodes and the cell outlet port 69.

The cell 70 is provided with a pair of electrodes including a cathode assembly 91 and an anode assembly 92. The cathode 91 is preferably constructed of a platinum group metal, such as platinum itself, or platinum alloy. The cathode may be constructed either of a solid platinum group metal alloy or a plated or laminated alloy material. Other materials may also be suitable for some applications, such as carbon or lead dioxide. Each type has certain disadvantages; the preferred platinum group metal cathodes, while the most desirable, are the most expensive. Carbon anodes deteriorate rapidly to the point of adversely affecting the efficiency of the cell. Lead dioxide is moderately acceptable but it must be ensured that the lead does not contaminate food processing or other like areas. The anode 92 need not be constructed of a platinum group metal but should be constructed of a non-corrosive material. Several commercially available titanium and nickel alloys are suitable for this purpose. The electrode assemblies 91 and 92 include the lower immersible portions 93 and upper support portions 94 which extend through the cell head 85. The support portions 94 are adapted to secure the electrodes 91 and 92 to the cell head and are provided with threaded ends by which they may be tightened to the head 85 through the use of the nut and washer assemblies 96. Above the nut and washer assemblies 96 on the electrode support portions 94 are provided other means, such as additional nuts and washers 97, to enable the electrodes to be connected to appropriate wire conductors. A pair of tapered neoprene washers 99 surround the support portions 94 beneath the nut and washer assemblies 96 to form seals

between the supports 94 and the head 85.

The electrodes are supported at their lower portions 93 by two pairs of polyvinyl chloride spacers 102 which surround nylon bolts 101. Attached to the lower end of one of the electrodes is a baffle member made of an acrylic plastics material 104 which is provided in order to prevent the pulsating saline solution which enters the chamber from port 66 from spurting between the electrodes 91 and 92 and cyclically varying the electrical properties of the condensing solution. Such spurting causes a pulsating current flow through the cell and renders the cell operation difficult to monitor and regulate. By providing the baffle 104, a more uniform and homogenous solution is maintained within the cell cavity 86. This also causes a more uniorm electrolyzing current to flow between the electrodes by reducing the pulsating change with time of the properties of the solution between the electrodes. To direct the solution along an axial path between the electrodes, a pair of non-conductive plates 105 extend between each of the opposite edges of the electrodes from their tops to approximately one-half inch from their bottom ends. The plates 105 are preferably transparent to facilitate inspection

Referring again to Fig. 1, the electrical control circuit 110 includes a power supply which connects to the AC line 28 through a pair of fuses 112 and the on/off switch 23 located on the panel 27. The switch 23 is a double-pole single-throw switch which connects either 110 or 220 volt AC power to the unit line voltage lines 113 and 114. The lines 113 and 114 are connected across the primary winding 115 of a step-down transformer 116 which has a 24 volt secondary winding 117. A power "ON" indicator light 24 is connected across the winding 117. One of the terminals 121 of the transformer secondary winding 117 is connected to the wiper contact 122 of the wand trigger switch 38 through the cable 37. The switch 38 is also provided with a normally-opened OFF contact 124 and two contacts 125 and 126, which are connected through relay windings 131 and 132 respectively to the other secondary terminal 118 of the transformer 116.

The relay 131 is actuated when the trigger switch 38 is in the flush position 125. This relay 131 operates relay contact set 131-1 which connects the solenoid winding 72 across the AC lines 113 and 114. Similarly, a contact set 132-1 is connected in parallel across the contacts 131-1 to similarly energize the solenoid 72 when the switch 38 is in the sanitizing position. A second set of contacts 132-2 of the relay 132 operates, when the switch 38 is in the sanitize position, to connect the winding of the motor 59 across the lines 113 and 114. Connected across the motor winding leads 142 is the primary winding 144 of a transformer 145. The transformer 145 is a step-down transformer having an approximately 20 volt output secondary winding 146. The center tap 147 of the secondary 146 is connected through the current meter 25 to the cathode 91 of the cell 70, the anode 92 of the cell 70 being grounded. The opposite ends of the winding 146 are connected to the anodes of a respective one of a pair of diodes 151, each of which has its cathode connected to ground at point 152. The center tap 147 furnishes a rectified full-wave negative output to the cathode 91 of the cell 70.

To initially condition the central unit 20, the brine tank 52 is filled with approximately 20 pounds of granulated and non-iodized table salt. Then by connecting inlet port 29 to tap water at a pressure of about 40 to 65 psi, the tank 52 is filled until float valve 81 shuts off the flow. The flow of the tap water causes switch 80 to energize pump 77 wihch pumps prescribed quantities of acid into tank 52. When this is completed, the valves 73 and 64 are opened to ready the unit for spray operation.

In operation, an operator orients the wand 30 so that the nozzle 42 is directed towards the objects 11 or 12, the surfaces of which are to be disinfected. The operator can initiate the sanitizing procedure by actuating the switch 38 to the sanitize position, thereby actuating the relay 132 and closing the sets of contacts 132-1 and 132-2 to energize the solenoid 72, opening the valves 71, causing clear water to flow into the inlet 66 of the cell 70. Also, the closing of the relay contacts 132-2 energizes the pump motor 59, causing the pump 58 to pump saline solution which mixes with the clear water at the "T" 63 to enter the inlet 66 of the cell 70. Simultaneously, the rectifier 140 is energized to supply electrilyzing current to the cell 70 to electrolyze the solution flowing through the cell 70, causing a chlorinated disinfecting solution to be emitted from the cell outlet 69 through the "T" 68 and the central unit outlet 31, through the hose 32 and the inlet 35 of the wand 30 and then through the tube 43 of the wand 30 and out of the nozzle 42 in the form of a continuous liquid stream upon the objects 11 and 12.

The salinity of the solution, and thus the chlorine strength of the generated solution, is controlled by coordinating the settings of the cam on the pump motor shaft 61 to control the displacement of the pump 58 with the setting of the valve 73 in the clear water input line. For example, if the ratio of the incoming fresh water to the brine solution is maintained at about 72:1,

a six inch electrolytic cell will generate 100 parts per milion of free chlorine (substantially entirely in the form of hypochlorous acid) at one-half gallon per minute flow rate. The six inch cell refers to a cell wherein the electrodes are each 6" × 2 1/4" and operated at 14-17 volts across the electrodes and at a current of 25-30 amps. The solution may be further diluted to reduce the parts per million of chlorine where the particular sanitizing application admits of a lower proportion of chlorine. Further dilution as, for example, up to 100:1 does not adversely affect the pH of the solution, assuming the pH of the incoming fresh water is 7. Where the pH of the incoming water is more alkaline, the pump 77 should be varied to increase the proportion of acid in the solution from two ounces per gallon of saline solution.

A bactericidal solution having a substantially greater chlorine concentration may be prepared by using larger cells and ~~connecting them in series. For example,~~ the concentration can be increased to two thousand parts per million or even greater should a particular situation require it.

As indicated above, the invention has particular application to the disinfecting of meat carcasses. The low pH electrolytically generated chlorinated solution, may be utilized in any one of several different ways. For example, one operator employing a single nozzle might spray a carcass for about thirty seconds at a rate of at least ½ gallon of solution per minute, the solution having a chlorine concentration of from twenty-five to two hundred parts per million. Alternatively, the carcass could be subjected to a multiple nozzle spray as, for example, twelve nozzles spraying for about ten seconds.

Still another method involves the prewashing of the carcass with portable tap water followed immediately by creating a dense fog of the solution of the invention surrounding the carcass. In the latter method, the volume rate of spray is markedly reduced.

WHAT WE CLAIM IS:—

1. A method of disinfecting a bacteria-laden surface, which comprises
(a) electrolysing an aqueous solution of sodium chloride having a pH of from 6 to 7, so as to generate nascent chlorine at least 80% of which is in the form of hypochlorous acid, and
(b) substantially immediately applying the solution of nascent chlorine thus generated to the bacteria-laden surface.

2. A method according to claim 1, in which the solution of nascent chlorine is applied to the surface by spraying in the form of a liquid stream at a rate of at least half a gallon per minute.

3. A method according to claim 1 or 2, in which the solution of nascent chlorine is sprayed on to the surface to be disinfected from a portable nozzle.

4. A method according to any of claims 1 to 3, in which the surface to be disinfected is the surface of a meat carcass.

5. A method according to claim 4, in which the solution sprayed on to the carcass has a chlorine concentration of from 25 to 200 parts per million.

6. A method according to claim 4, in which the carcass is washed with potable water immediately prior to the application of the bactericidal solution, and in which the bactericidal solution is applied to the carcass in the form of a dense fog surrounding the carcass.

7. A method of disinfecting a bacteria-laden surface according to claim 1, substantially as herein described.

~~8. An apparatus for use in disinfecting~~ a bacteria-laden surface by the method according to claim 1, which comprises
(A) a movable apparatus in which the disinfecting solution is generated, which comprises
(i) a source of saturated saline solution
(ii) an electrolysis cell, comprising an inlet, an outlet, a non-corrodable cathode formed of a Platinum Group metal and a non-corrodable anode,
(iii) means for supplying acid to the saline solution,
(iv) means for supplying make-up water to the saline solution,
the means for supplying acid and make-up water to the saline solution including means for adjusting the relative amounts of water and acid supplied,
(v) means for supplying the acidified solution together with water to the electrolytic cell,
(vi) meansf or passing saline solution through the cell from the inlet to the outlet past the electrodes, and
(vii) means for supplying a DC voltage across the electrodes to cause a DC current to flow through the solution and thus to generate nascent chlorine in the solution,
(B) a portable and independently movable wand having an inlet, an outlet, and a passage through the wand connecting the inlet and the outlet,
(C) a connection between the inlet of the wand and the outlet of the electrolysis cell which allows liquid to pass from the electrolysis cell to the wand,
the wand and the means for passing liquid through the electrolysis cell being adapted to allow chlorinated solution from the electrolysis cell to be emitted from the outlet of the wand as a continuous stream of

liquid on to the surface to be disinfected.

9. An apparatus according to claim 8, substantially as herein described with reference to Figures 1 to 3 of the accompanying drawings.

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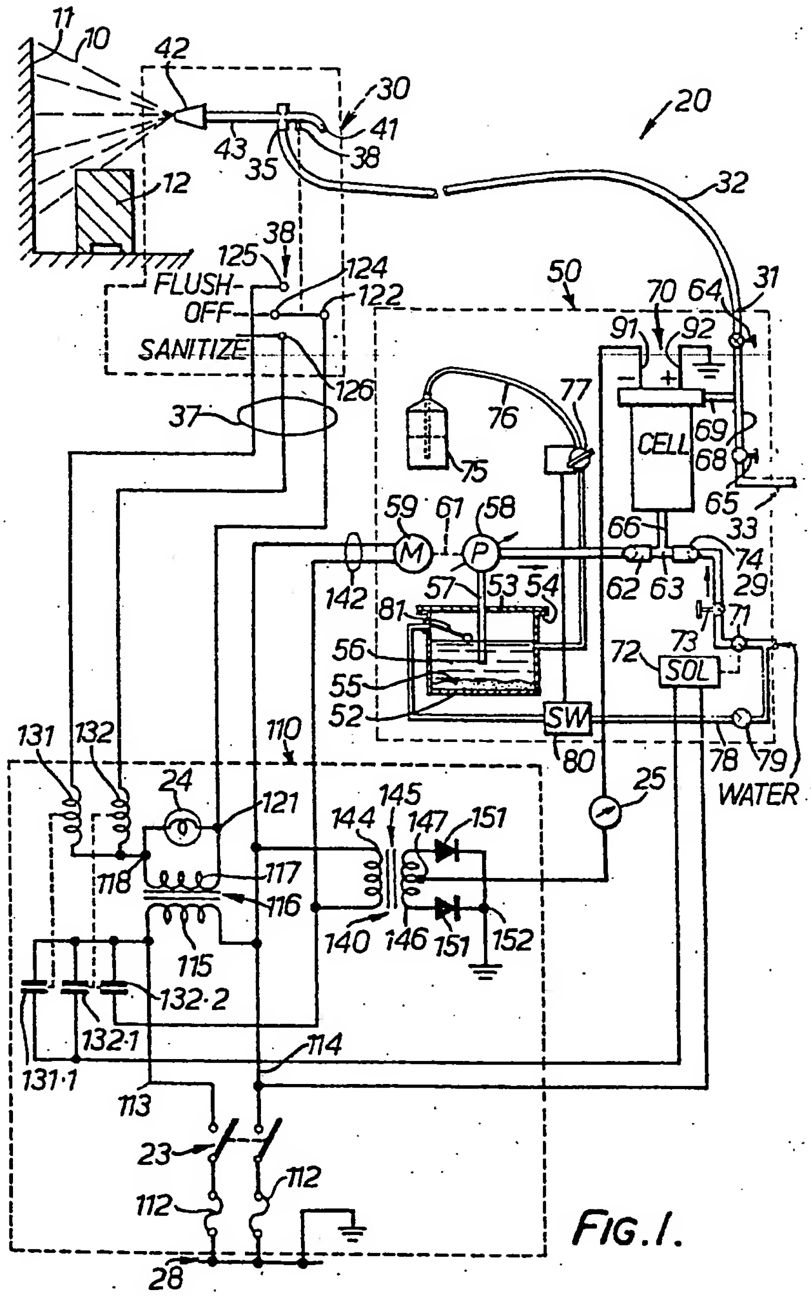


FIG. 1.

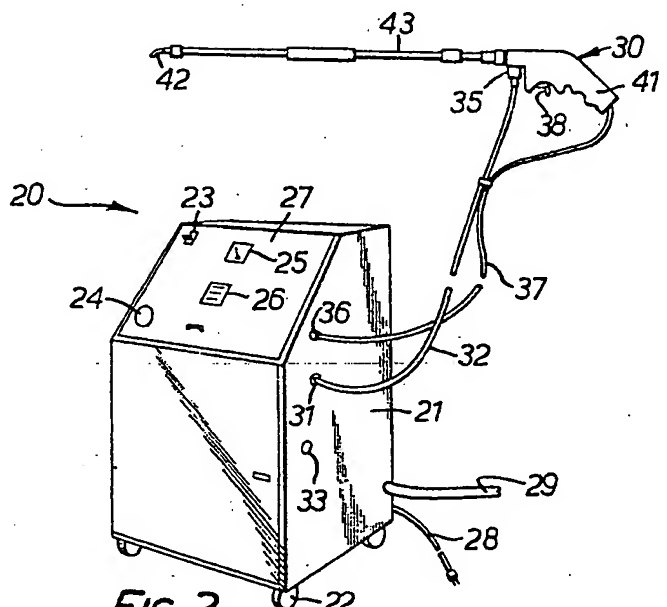
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FIG. 2.

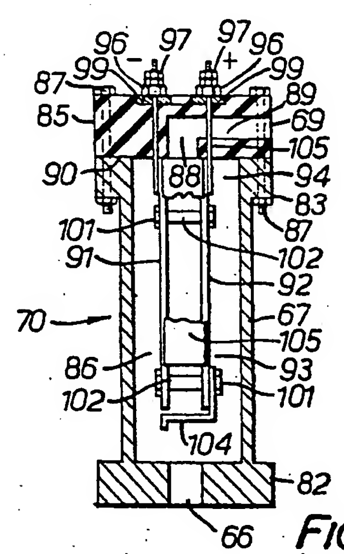
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FIG. 3.